Working Paper Series no. 34
RP – Markets, Institutions and Policies

A Review of the National Biofuel Policy in India: A critique of the Need to Promote Alternative Feedstocks

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2012

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1. Introduction

Energy is a critical input for economic growth and sustainable development in both developed and developing countries. The world's energy requirement for transportation is met from non-renewable fossil fuels. The sharp rise in crude oil prices from US$20 a barrel in 2002 to almost US$100 (even touching US$140 before stabilizing at around US$80) has forced nations to seriously consider alternative energy sources that are renewable and non-polluting. In the face of shrinking supplies and rising demand, oil prices are expected to continue to rise. In addition, growing concerns about human-induced climate change, as evidenced by rising temperatures and environmental pollution, are further driving the impetus for non-polluting energy sources. One such source is ethanol from plant biomass/grain and biodiesel from processing edible and non-edible vegetable oils.

A mandatory 5-10% blending of biofuels with petrol and diesel stipulated by some countries in the last 10-20 years triggered a rapid growth in the biofuel sector in the last decade. By 2007-08, world biofuel production had touched 62.2 billion tons (t), of which around 88% was in the form of ethanol. The two largest ethanol producers, Brazil and the United States of America (USA), account for almost 87% of its total production. Biodiesel production that accounts for a smaller proportion of liquid biofuels, increased from 0.01 million t in 1991 to 9.0 million t by 2008. The European Union (EU) produces over 60% of the global share with a significantly smaller contribution coming from the USA (17%).

The key raw materials for bioethanol production are sugarcane in Brazil, corn in the USA, corn and wheat in China and molasses in India. In the case of biodiesel, the main feedstocks are vegetable oils from rapeseed, mustard, soybean, sunflower and palm oil. However, the biofuel industry is still at a nascent stage requiring Government support in terms of lower taxes and other infant industry incentives. Since raw materials for biofuels originate from the farm sector, ensuring adequate incentives for farmers to grow biofuel crops without compromising on food security is critical. Several nations like the USA, Brazil, the Philippines, China and the European Union have in place biofuel policies that have a bearing right from the production of biofuel crops at the farm level to their conversion into transport grade biofuels at the distillery for use in blending.

This paper highlights the salient features of India's biofuel policy, particularly pertaining to bioethanol, and discusses how it influences the sustainability and commercialization of ethanol production in the country. In India, molasses (a byproduct of sugar production) is the main raw material for ethanol to meet the country's mandated blending requirements. The paper also addresses the long-term sustainability of ethanol production from molasses for blending mandates. Finally, the viability of using an alternative feedstock like sweet sorghum that is grown in the drylands for bioethanol production and policy options for its promotion are explored.

2. Energy Demand in India

India's energy demand is primarily met through non-renewable sources such as coal, natural gas and oil. These will continue to play a dominant role in its energy scenario in the next few decades. The highest demand for energy comes from industry, followed by the transportation sector which consumed about 16.9% (36.5 m of oil equivalent) of the total energy (217 million t) in 2005-06

(TERI 2007). Within the transportation sector, the consumption of motor spirit (gasoline) grew by 6.64%, from 7.01 million t in 2001-02 to 11.26 million t in 2008-09 and that of high speed diesel (HSD) by 4.1%, from 36.55 million t to 51.67 million t (GOI 2009). This growth will only escalate over the next several years since India's vehicular population is expected to grow by 10-12% per annum. Hence securing a long-term supply of energy sources and prioritizing development are critical to ensuring the country's future energy requirements are met. Currently, the country is looking for alternative energy options from biofuels to meet the transportation sector's demand. To promote biofuels as an alternative energy source, the Government of India stipulated mandatory blending requirements of gasoline with biofuels, aided by policy incentives designed to facilitate optimal development and utilization of indigenous biomass feedstocks for biofuel production.

3. India's Biofuel Policy

In 1948, the Power Alcohol Act heralded India's recognition of blending petrol with ethanol. The main objective was to use ethanol from molasses to blend with petrol to bring down the price of sugar, trim wastage of molasses and reduce dependence on petrol imports. Subsequently, the Act was repealed in 2000, and in January 2003, the Government of India launched the Ethanol Blended Petrol Programme (EBPP) in nine States and four Union Territories promoting the use of ethanol for blending with gasoline and the use of biodiesel derived from non-edible oils for blending with diesel (5% blending). In April 2003, the National Mission on Biodiesel launched by the Government identified *Jatropha curcas* as the most suitable tree-borne oilseed for biodiesel production.

Due to ethanol shortage during 2004-05, the blending mandate was made optional in October 2004, and resumed in October 2006 in 20 States and 7 Union Territories in the second phase of EBPP. These ad-hoc policy changes continued until December 2009, when the Government came out with a comprehensive National Policy on Biofuels formulated by the Ministry of New and Renewable Energy (MNRE), calling for blending at least 20% biofuels with diesel and petrol by 2017.

National Policy on Biofuels: An Overview

Salient Features

- An indicative target of 20% blending of biofuels both for biodiesel and bioethanol by 2017
- Biodiesel production from non-edible oilseeds on waste, degraded and marginal lands to be encouraged
- A Minimum Support Price (MSP) to be announced for farmers producing non-edible oilseeds used to produce biodiesel
- Financial incentives for new and second generation biofuels, including a National Biofuel Fund
- Biodiesel and bioethanol are likely to be brought under the ambit of "declared goods" by the Government to ensure the unrestricted movement of biofuels within and outside the states

- Setting up a National Biofuel Coordination Committee under the Prime Minister for a broader policy perspective
- Setting up a Biofuel Steering Committee under the Cabinet Secretary to oversee policy implementation.

Several ministries are currently involved in the promotion, development and policy making for the biofuel sector.

- The Ministry of New and Renewable Energy is the overall policymaker, promoting the development of biofuels and research and technology development for its production.
- The Ministry of Petroleum and Natural Gas is responsible for marketing biofuels and developing and implementing a pricing and procurement policy.
- The Ministry of Agriculture's role is that of promoting research and development for the production of biofuel feedstock crops.
- The Ministry of Rural Development is specially tasked to promote Jatropha plantations on wastelands.
- The Ministry of Science & Technology supports research in biofuel crops, specifically in the area of biotechnology.

In view of the multiple departments and agencies involved, a National Biofuel Coordination Committee (NBCC) headed by the Prime Minister was set up to provide high-level coordination and policy guidance/review on different aspects of biofuel development, promotion and utilization.

4. Policy Challenges Affecting Biofuel Development

Biofuel policies play an important role in the development of the energy sector. The profitability of biofuel production is significantly influenced by policies affecting multiple sectors such as agriculture, research, industry and trade. Identifying relevant policies and quantifying their specific impacts is difficult given the variety of policy instruments (taxes, subsidies, price support, etc) and the way they are applied (FAO 2008).

For example, subsidies can affect the sector at different stages (Steenblik 2007). The various points in the biofuel supply chain at which direct and indirect policy measures can support the sector are interrelated, and assigning policies to one category or another may be somewhat artificial in practice (FAO 2008). Figure 1, adapted from the Global Subsidies Initiative of Steenblik (2007), has been used as a background to discuss the biofuel policy in India, its implications and distortions at various stages of the supply chain (production, commercialization and sustenance) in promoting the sector.

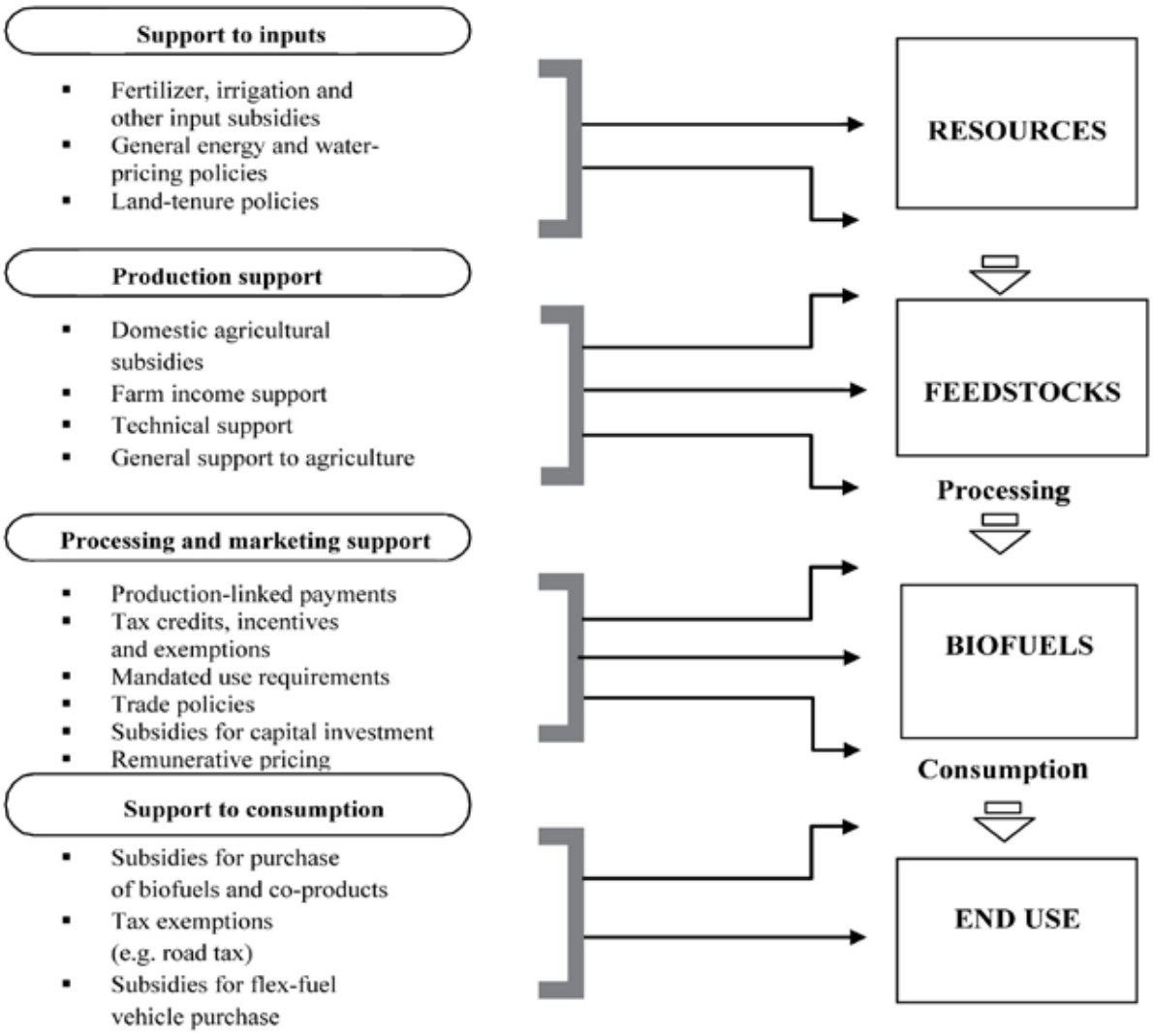

Figure 1. A framework adapted from the Global Subsidies Initiative of Steenblik (2007) showing the policy support required along the biofuel supply chain.

Blending Mandates

Imposing quantitative targets in the form of blending mandates is the key driver in the development and growth of the biofuel industry. The blending mandate of 5% ethanol with gasoline in nine states of India in 2003 was enhanced to include 20 states in 2006. In 2010, the National Policy on Biofuels approved a target 20% blending with biofuels by 2017.

In India, the main raw material for ethanol production is molasses, a byproduct of sugar production. Supply of sugarcane and molasses production are dependent on sugar cycles. During 2006 and 2007, due to excess supply of cane and molasses, prices were depressed. The mandated blending targets were probably based on the surplus ethanol available during a good sugarcane production year. Between 2003 and 2008, the price of molasses fluctuated considerably, from ₹50 t^{-1} to ₹6000 t^{-1} (US$1.1 - 133.3). Additionally, there is competition from the potable and chemical

industries for alcohol from molasses. During a normal year, cane converted into sugar generates enough molasses to produce alcohol to meet the needs of potable and chemical sectors (30-40% each) with another 20-30% surplus alcohol available for conversion into ethanol and related products.

During 2009, the total supply of ethanol was 2.4 million t, sufficient to meet the total demand of 1.80 million t from all three sectors (@5% blending target for ethanol). Despite this, the blending target could not be met since Oil Marketing Companies (OMCs) were unable to procure the required fuel ethanol at prevailing market prices that are lower than alcohol prices for different uses. The Indian Chemical Council has estimated that even at 5% blending, a deficit of 2040 million liters is projected by 2014-15, assuming constant production of molasses and alcohol (Table 1). A study by Shinoj et al. 2011 finds that as per the 20% blending target set by the government, the demand for fuel ethanol is projected to be 1.93 million t and total demand (ethanol + alcohol) as high as 3.52 million t.

Table 1. Projected demand and supply of alcohol in India.

Alcohol requirement (million liters)	2011-12	2012-13	2013-14	2014-15
Potable sector	1550	1660	1780	1900
Industrial sector	1100	1160	1210	1280
Blending (5%)	1090	1150	1200	1260
Total alcohol required	3740	3970	4190	4440
Highest expected alcohol availability (million liters)	2400	2400	2400	2400
Deficit (million liters)	(1340)	(1570)	(1790)	(2040)

Source: Indian Chemical Council.
Note: Based on past trends, the growth rates are assumed to be 5% for the industrial sector, 7% for the potable sector and 5% for blending.

The question that arises is, how can we meet the blending requirement of bioethanol at 5%, 10% and 20%? Can we boost ethanol production from molasses or do we need to promote alternative feedstocks? The biofuel policy can address this by prioritizing feedstock-targeted blending mandates that will give a boost to alternative feedstocks besides molasses and make them viable for ethanol production.

Input Support (Subsidies)

The justification for providing policy support to a new sector is based on its ability to overcome initial costs of technological innovation and market development required to make it competitive. This is the “infant industry” argument for providing subsidies. However, providing subsidies to a sector that will not ultimately achieve economic viability is not sustainable and may only serve the purpose of transferring wealth from one group to another while imposing costs on the economy as a whole (FAO 2008).

In India, most inputs like fertilizer, pesticide and electricity to irrigate crops are subsidized. The quantum of crop subsidy varies with the inputs used for its production. The inputs utilized in cane production – seed, implements and tools, electricity to pump water, fertilizer and pesticide

– are highly subsidized. These subsidies accrue indirectly to molasses used in the production of ethanol.

Output Support

Besides production support, output support for the purchase of biofuels is critical. The National Biofuels Policy proposes a Minimum Support Price mechanism for *Jatropha* whose seed is used to produce biodiesel. In the case of sugarcane, the existing statutory minimum price provides effective protection to growers. The policy specifically targets ethanol production from currently available sugarcane molasses. In the case of biodiesel, while the policy proposes that the Minimum Purchase Price (MPP) be linked to the prevailing retail price of diesel, for bioethanol it is based on its actual cost of production and import price. The demand for alcohol at higher prices from the chemical and potable sectors dictates ethanol pricing while at the same time constraining supply to the biofuel industry. Experience indicates that OMCs are unable to procure ethanol at the prevailing price for effecting blending mandates as the sugar industries obtain a better price and assured demand from beverage and pharmaceutical industries (Shinoj et al. 2011).

Processing and Marketing Support

Oil Marketing Companies in 20 states and 4 Union Territories have been assigned the task of blending 5% ethanol with gasoline. The sugar industry has been permitted to produce and process ethanol from sugarcane juice to augment production to meet blending requirements. Other than molasses and sugarcane, the policy does not specify in concrete terms processing alternative feedstocks for bioethanol. Alternative feedstocks like sweet sorghum and sugar beet are mentioned in the policy but there is no concrete roadmap suggested for their promotion.

Distribution and Marketing of Biofuels

Oil Marketing Companies have been responsible for the storage, distribution and marketing of biofuels in India. India's biofuel policy exempts the biofuel sector from central taxes and duties. While biodiesel is exempt from excise duty, bioethanol enjoys a concessional excise duty of 16%. Customs and excise duty concessions are also provided on plant and machinery for the production of biodiesel and bioethanol. While these policies promote the biofuel sector, those promoting the production of feedstock need to be highlighted in order to fully realize the benefits provided on the processing front, since production and processing are interdependent. Though the policy mentions exemption of central taxes and duties on biofuels, sales tax, license fee, permit fee and import taxes still exist, hindering the growth and development of the industry. The policy provides no additional incentives for blenders and retailers of biofuel unlike in other countries.

Subsidies in other countries: Several countries are subsidizing or mandating investments in infrastructure for biofuel storage, transportation and use, most of it directed towards ethanol which normally requires major investments in equipment. Such support is often justified on the grounds that greater use of ethanol and expansion of its market will not occur until sufficient distribution infrastructure and sales points are in place (FAO 2008). For example, in the United States, the American Jobs Creation Act of 2004 introduced the Volumetric Ethanol Excise Tax Credit (VEETC),

a tax credit of 51 cents per gallon of ethanol for blenders and retailers. The VEETC was expanded to include biodiesel in 2005. The European Union (EU) rural development policy provides grants as capital costs for setting up biomass production plants.

Though such sops are mentioned in India's policy to promote the biofuel industry, they have not been implemented at the ground level. Oil Marketing Companies in India have well established infrastructure and manpower. Given their available resources and expertise, options to set up biofuel processing plants can be explored. The capital costs involved could be subsidized by the Government in the initial phase. Also, production centers can cater to both bioethanol and biodiesel needs and also aid in developing the biofuel industry to benefit all stakeholders. This could be done on a pilot basis since more information is required for upscaling and outscaling.

Consumption Support

The biofuel policy's thrust is on the supply side even though demand side factors also play a major role in promoting biofuels. For example, many countries actively promote flex-fuel vehicles designed to use a higher percentage blend of ethanol with petrol than ordinary vehicles through reduced registration fees and road tax exemptions. Similarly, support is provided to purchase biofuels, co-products and flex-fuel vehicles.

Under Section 52 of India's Motor Vehicles Act, an existing vehicle's engine can be modified to use biofuels. Hence, engine manufacturers need to suitably modify engines to ensure compatibility with biofuels. Demand for such vehicles and consequently biofuels can be stimulated by providing road tax exemption and reduced registration fee for vehicles running on blended fuels. Incentives similar to the ones approved by MNRE for the dissemination and promotion of battery-operated vehicles (BOV) will also help in augmenting the biofuel industry.

Financial and Fiscal Incentives

Apex financial institutions like the National Bank for Agriculture and Rural Development (NABARD), Indian Renewable Energy Development Agency (IREDA) and Small Industries Development Bank of India (SIDBI) have refinancing provisions to set up biodiesel plantations, oil expelling/ extraction units, and infrastructure for storage and distribution The lending towards these sectors would be classified as priority sector lending. The policy states the consideration of subsidies and grants upon merit for new and second generation feedstocks; advanced technologies and conversion processes; and production units based on new and second generation feedstocks. Similar emphasis explicitly mentioning bioethanol would benefit the ethanol industry.

Research & Development

The policy's major thrust is innovation, Research & Development (R&D) and demonstration. It focuses on R&D efforts in processing and production technologies and maximizing efficiencies and utilization of byproducts along the biofuel value chain. Demonstration projects are to be set up for biodiesel and bioethanol production, focusing on conversion technologies through Public Private Partnership (PPP). Grants are to be provided to academic institutions, research organizations, specialized centers and industry for promising R&D and demonstration projects.

Institutional Mechanisms

Among institutional policies that promote the biofuel industry are international cooperation through technical collaboration in production, conversion and utilization; trade in biofuels; state participation in planning and implementing biofuel programs; and capacity building for dissemination and creating awareness.

Though India has a policy on promoting biofuels at various stages of the supply chain, the government's initiatives on the production and commercialization fronts have not taken off as anticipated to meet the energy demand for ethanol and biodiesel.

Sustaining Bioethanol Production to Meet Blending Mandates

The biofuel policy states that a level playing field is necessary for accelerated development and utilization of biofuels vis-a vis direct and indirect subsidies to fossil fuels and distortions in energy pricing. To augment ethanol availability and reduce the oversupply of sugar, the policy permits the sugar industry to directly produce ethanol from sugarcane juice. The policy implies further concessions to sugarcane growers and processors who are already benefitting from the input subsidy. Sugarcane has the advantage of existing massive infrastructure and favorable government policy support since earlier years. This has led to policies tailored favoring ethanol production from sugarcane and molasses. However, this is counterintuitive to the policy recommendation of using degraded and less fertile land for biofuel production. The lopsided policy that implies concessions for ethanol production through sugarcane could have a detrimental effect on resource allocation in the agriculture sector.

However, considering the demand for sugar in India, it is highly unlikely that sugarcane juice will be used for ethanol production. The analysis conducted by Shinoj et al. (2011) has shown that it is highly unsustainable to extend sugarcane area beyond a limit, given that the crop is highly water intensive, requiring 20,000-30,000 m^3 ha^{-1} per crop.

Given the lopsided policy coupled with non-availability, economic viability and sustainability of ethanol from molasses, the EBPP has not been successfully implemented. This calls for augmenting bioethanol production to meet blending mandates through policy support for alternative feedstocks. One such alternative feedstock that has been pilot tested in recent years is sweet sorghum. Though the policy document mentions feedstocks like sweet sorghum, sugarbeet, etc, for ethanol production, these crops have neither been given due prominence in the policy nor has a clear roadmap been specified for their commercialization and utilization. Policy support mechanisms to promote alternative feedstocks will benefit all the stakeholders in the bioethanol supply chain in the long run while meeting the mandated requirements.

5. Sweet Sorghum as an Alternative Source of Bioethanol Production

Sweet sorghum stalk has been found to be a potential source of raw material for commercial ethanol production. Sweet sorghum does not compromise on food, feed or fodder production when used for energy production, thereby meeting the biofuel program's vision of not compromising on food security[1].

Sweet sorghum cultivation involves the judicious use of scarce resources like water and other inputs. The crop uses less than a third of the inputs used by sugarcane, such as water, electricity and fertilizers, making it a promising alternative feedstock (Reddy et al. 2008; Srinivasa Rao et al. 2009, Table 2). Sweet sorghum scores favorably on all parameters compared to alternative feedstocks. As per a pilot study conducted by Vasantdada Sugar Institute (VSI), Pune, India sweet sorghum-based ethanol production has 25% of the biological oxygen dissolved (BOD), ie, 19,500 mg liter^{-1} and lower chemical oxygen dissolved (COD), ie, 38,640 mg liter^{-1} compared to molasses-based ethanol production. Hence, besides molasses, there is a need for clear guidelines to promote alternative feedstocks like sweet sorghum.

Table 2. A comparison between sweet sorghum, sugarcane and sugar beet as feedstocks for ethanol production.

Crop	Cost of cultivation (US$ ha^{-1})	Crop duration (months)	Fertilizer requirement (N:P:K kg ha^{-1})	Water requirement (m^3)	Ethanol productivity (liters ha^{-1})	Average stalk yield (t ha^{-1})	Productivity per day (kg ha^{-1})
Sweet sorghum	435 over two crops	4	80:50:40	8,000 over two crops	4,000 year^{-1} over two crops [a]	50	416.67
Sugarcane	1,079 crop^{-1}	12 −16	250 to 400 - 125 -125	36,000 crop^{-1}	6,500 crop^{-1} [b]	75	205.47
Sugarcane molasses	-	-	-	-	850 year^{-1} [c]	-	-
Sugar beet		5-6	120:60:60	8,000–10,000	6,000–6,400 [d]	75-80	500-444

[a.] 50 t ha^{-1} millable stalk per crop @ 40 l t^{-1}.
[b.] 85-90 t ha^{-1} millable cane per crop @ 75 l t^{-1}.
[c.] 3.4 t ha^{-1} @ 250 l t^{-1}.
Source (d,e): Dayakar Rao et al. (2004).
[d.] Source: Shinoj et al. (2011); 75-80 t ha^{-1} of sugar beet @ 80 l ton^{-1}.
Source: Reddy et al. (2005).

Field surveys conducted by ICRISAT in Ibrahimbad, Medak district, Andhra Pradesh in 2008 under the National Agricultural Innovation Project (NAIP) revealed that the cost of inputs (fertilizer and imputed cost of irrigation) in the cultivation of sugarcane was ₹6691 ha^{-1} compared to ₹1948 ha^{-1} for sweet sorghum. Sugarcane cultivation requires higher amounts of scarce resources such as irrigation water and fertilizers which are highly subsidized. It requires nearly 160-180 ha cm of irrigation water while sweet sorghum is cultivated under rainfed conditions.

[1]The grain can be harvested for food and the bagasse left over after juice extraction from the stalk is an excellent feed for livestock.

Table 3. Crop-wise distribution of input subsidies per hectare in India (2000-01).

Crop	Fertilizer subsidy to total subsidy (%)	Electricity & canal subsidy to total subsidy (%)	Subsidy of crop area (₹ha^{-1})
Paddy	31.43	31.01	3587
Sugarcane	5.51	4.95	6099
Sorghum	3.55	1.01	839
Maize	2.64	1.87	1634
Total (billion ₹)	138.0	366.40	

Source: Acharya and Jogi (2004).

Additionally, crop-wise estimates of input subsidies during 2000-01 (Table 3) show that sugarcane had the highest input subsidy of ₹6099 ha^{-1} while sorghum had the lowest. The difference in irrigation subsidy alone provided to sugarcane was ₹1444 ha^{-1} relative to sorghum.

6. Tweaking Policies to Support Alternative Feedstocks

Economics of Sweet Sorghum Cultivation and Processing

As mentioned earlier, the justification for providing policy support to any new sector is based on its ability to overcome initial costs of technological innovation and market development required to make the sector competitive. This is the “infant industry” argument for providing support.

Data on cost of cultivation for sweet sorghum collected by ICRISAT over a period of 3 years across various locations under the project on value chain model for bio-ethanol production in India, funded by NAIP, ICAR and the Government of India, shows that sweet sorghum stalk yields have varied between 14 and 18 t ha^{-1}. With the buy-back price of sweet sorghum stalk at ₹700-1000 t^{-1}, sweet sorghum cultivation is competitive with other dryland crops in Ibrahimbad in Medak district of Andhra Pradesh (Table 4). Across clusters in Western Maharashtra too, sweet sorghum was found to be profitable with competing crops like sorghum intercropped with pigeonpea and sole sorghum. However, it becomes less competitive when compared to commercial crops like cotton and soybean in Maharashtra clusters. The high opportunity cost of land for cultivation forces the distillery to pay higher prices for sweet sorghum cultivation (if fertile land used for cotton and soybean cultivation has to be replaced with sweet sorghum).

Sweet sorghum is economically the next best alternative to molasses for ethanol production (Table 5), when the feedstock is priced at ₹800 t^{-1} of stalk. However, feedstock and ethanol pricing have a bearing on the viability of ethanol production from all available feedstocks.

Table 4. Benefit-cost ratio of sweet sorghum cultivation compared to competing crops, Ibrahimbad, Andhra Pradesh.

	Benefit-cost ratio		
Crop	2008	2009[1]	2010[1]
Sweet sorghum	1.55	0.96	0.81
Maize-pigeonpea	1.30	NA	0.97
Sorghum-pigeonpea	1.37	0.97	0.59

[1]The low returns from crops in these two years were due to adverse climatic conditions.

NA= Not available.

Table 5. Relative economics of ethanol production from different feedstocks in India.

Parameter	Sweet sorghum	Sugarcane molasses	Sugarcane juice	Grains (pearl millet and broken rice)
Cost of raw material (₹ t^{-1})	8^{0}01	3,000-5,000[2]	1200[3]	7,000[3]
Cost of processing (₹ t^{-1})	384	1,890	490	2,400
Total cost of production (₹ t^{-1})	1,184	4,890-6,890	1690	9,400
Output of ethanol (liters)	45	270	70	400
Value of ethanol (₹ t^{-1})	1,215	5,805	1505	8,600
Net returns (₹ t^{-1})	31	915 to -1,085	-185	-800
Cost of feedstock (Rs $liter^{-1}$)	17.77	11.11-18.51	17.14	17.5
Ethanol cost $liter^{-1}$ (₹)	26.31	18.11-25.51	24.14	23.5
Profit from ethanol (₹ $liter^{-1}$)	0.68	3.39 to -4.01	-2.64	-2

1. When the feedstock price is ₹800, it becomes profitable to produce ethanol from sweet sorghum without accounting for capital costs and valuing by-products. However, the cost of feedstock has varied between ₹700 and 1000 t^{-1}.
2. Molasses prices have ranged between ₹3000 and 5000 t^{-1} during the last few years. Hence the profitability of producing ethanol from it is highly dependent on fluctuating molasses prices.
3. Data on other feedstock cost is for the year 2009. The price of feedstock (sugarcane and grains) has increased in recent years.

Source: Authors' calculations are based on the data collected from the ICRISAT project on Sweet sorghum for ethanol production funded by NAIP-ICAR.

On the processing side, an assessment of economic viability was carried out by the authors using data from a distillery crushing sweet sorghum for ethanol production. The distillery had a buy-back arrangement with farmers; it was paying ₹1200-1300 t^{-1} (US$24-26) of sweet sorghum stalk to farmers since they had to be compensated for the loss in returns from cultivating cotton and soybean. With feedstock price fixed at ₹1200-1300 t^{-1} of stalk and subsequent processing costs incurred by the distillery, ethanol has to be priced at ₹36 l^{-1} from the existing administered price of ₹27 l^{-1} to make the distillery viable.

Several scenarios were developed by varying feedstock, ethanol price and ethanol recovery rate in a sensitivity analysis. The analysis helped estimate the breakeven points and ethanol pricing scenarios for the sweet sorghum value chain.

Policy Support for Sweet Sorghum

The area under cultivation of alternative feedstocks is low due to higher feedstock prices, non-assured buy-back arrangement for farmers and low ethanol prices. The policy proposes an MSP mechanism for biodiesel crops while ignoring the same for bioethanol-producing crops like sweet sorghum and sugar beet.

In the current market context, policy support for the production of a biofuel crop primarily depends on the mutual/simultaneous co-existence of producers and processors to promote alternative feedstocks. For growers, it's the relative profitability of bioethanol crops vis-a-vis competing crops and assured buy-back at pre-determined prices that are important factors determining allocation of land for these crops. For industry, the raw material's conversion efficiency, its continuous supply for at least 5-6 months in a year, the economics of establishing multi-feedstock production units and the purchase price of ethanol by oil companies are critical factors. For industries producing ethanol from alternative feedstock, policy support should be in the form of a minimum purchase price to ensure at least a breakeven price of ethanol production.

Policies such as capping a third of the 5-10% requirement in the initial years will serve as an incentive to tap alternative sources of feedstock like sweet sorghum.

Converting any form of sugar to alcohol requires special permission and licensing (opinions based on visits to industries by ICRISAT scientists). Barriers to licensing and permission to convert multiple feedstocks to ethanol deter industry from processing. Moreover, depending on a single feedstock is unviable and not conducive to attaining optimal capacity and profitability. Easy licensing to set up and run multi-feedstock units that can operate for longer periods in a year can augment ethanol production.

Options can be explored with the sugar industry to integrate the crushing of sweet sorghum during lean periods of sugarcane crushing. Viability gap funding as undertaken for infrastructure projects in Public Private Partnership (PPP) mode can be explored to produce ethanol from sweet sorghum. "Infant industry sops" should be provided by the Government during the initial years until the industry achieves technological and efficiency breakthrough.

Sweet sorghum is a newly introduced, promising crop for bioethanol production. Research is on to develop promising cultivars for higher yield and juice content. There are pilot projects linking farmers to the bioethanol industry. Hence, funding support for ongoing research on sweet sorghum and its promotion are critical. Identifying institutional mechanisms through public-private partnerships and funding support by national and international agencies to promote such biofuel crops will go a long way in promoting alternative feedstocks.

Economic Viability and Cost of Subsidy

Studies across countries have calculated the point at which ethanol from various feedstocks would be competitive with fossil fuels as well as explored policy incentives and interventions to promote bioethanol. In the Indian context, there are arguments in favor of bioethanol; that it would become economical with higher crude oil prices [to the tune of US$147 a barrel (July 2008)].

The analysis by Shinoj et al. 2011 on the sustainability of sugarcane-based ethanol has shown that even in such a scenario, it would be difficult to meet the mandated ethanol blending requirement.

To determine the breakeven points of production of ethanol from sweet sorghum in the Indian context, the authors have replicated the Tyner and Taheripour (2007) framework using maize as feedstock relative to crude oil. The analysis takes into account current prices and conversion technology of the feedstock that could form the bases for price and policy incentives to promote biofuels from alternative feedstocks.

The breakeven price analysis shows that with a conversion rate of 4.5% of ethanol from sweet sorghum, the feedstock price should be ₹800 t^{-1} of stalk when the price of crude is at US$85 a barrel.

Currently, sweet sorghum growers are paid ₹700-1300 t^{-1} (US$14-26) of stalk by ethanol processors. The difference between the breakeven price and the market price (₹1200-₹1300 t^{-1} as the opportunity cost of cultivation) of sweet sorghum will help in determining the loss incurred by ethanol processors in producing ethanol from sweet sorghum. In other words, given the price of crude oil, ethanol producers can make profits even though the price of sweet sorghum increases, if the difference between the breakeven price and market price of sweet sorghum is compensated by support from the government.

Cost of subsidy: The authors have estimated the magnitude of support required if feedstocks like sweet sorghum are prioritized and promoted, supported by an enabling environment in India, taking into account the land required for its cultivation and ethanol production for blending mandates. Based on projections by the Planning Commission, 1.97 billion liters of bioethanol at the rate of 10% blending would be required by 2017. Currently, the blending need is fulfilled by OMCs from sugarcane molasses. Given the unsustainable scenario of ethanol production from molasses, ethanol could be produced from feedstock like sweet sorghum.

Since bringing a larger area under sweet sorghum cultivation in the short run is not possible and research and extension efforts would be required to make it a viable option for blending, it is assumed that only 5% of the total ethanol required for blending would come from sweet sorghum during 2012, and this would go up to 20% by 2020. Based on these assumptions, the annual requirement of bioethanol from sweet sorghum during 2012-14, 2015-19 and 2020 have been projected at 5%, 10% and 20% of the total ethanol required, respectively.

Based on these annual projections, the cumulative area needed to be brought under sweet sorghum cultivation by 2020 would be 0.5 million ha, a small proportion of the total area (around 3.5 million ha) presently under cultivation in *kharif* (rainy season) sorghum alone. The area under *kharif* sorghum in the state of Maharashtra is close to 1.2 million ha. Here we assume that initially sweet sorghum will replace *kharif* sorghum since both crops grow under similar conditions and the grain from sweet sorghum would compensate for the loss in sorghum grain.

Table 6. A projection of ethanol requirement in India by 2020, and the land and subsidy required to meet 20% of the demand from sweet sorghum.

Year	Ethanol required for blending (billion liters)	Ethanol required from sweet sorghum (billion liters)	Area required for cultivation of sweet sorghum at 20 t ha^{-1} (million ha)	Subsidy required (million ₹)
2006	1.20			
2007	1.26			
2008	1.31			
2009	1.37			
2010	1.44			
2011	1.50			
2012	1.57	0.079	0.087	105
2013	1.64	0.082	0.091	110
2014	1.72	0.086	0.096	115
2015	1.80	0.180	0.200	240
2016	1.88	0.188	0.209	251
2017	1.97	0.197	0.219	262
2018	2.06	0.206	0.229	274
2019	2.15	0.215	0.239	287
2020	2.25	0.450	0.500	601

On-farm sweet sorghum stalk productivity is expected to increase from 20 t ha^{-1} to 30 t ha^{-1} between now and 2020 with improved cultivars, better management practices and increased awareness of farmers about sweet sorghum cultivation. With increased productivity, a larger area could be brought under cultivation, thereby increasing ethanol available for blending.

The estimated breakeven price of sweet sorghum for ethanol production is ₹1200 t^{-1} (including the cost of processing) at 4.5% recovery, when crude is priced at US$85 a barrel. Based on the estimated breakeven price, if a support of ₹1200 ha^{-1} (one third of what is provided for crops like paddy and sugarcane) is provided to processors, the total economic cost of subsidies for sweet sorghum production would range between ₹105 million (US$2.33 million) and ₹601 million (US$13.35 million) by 2020 based on the area required for sweet sorghum cultivation (Table 6). Comparing the subsidies provided to water-intensive crops like sugarcane and paddy in India which account for an average of ₹3000-4000 ha^{-1} and those provided in the United States and EU for biofuel production, the estimated quantum of support for sweet sorghum is modest.

7. Conclusion

While the policy framework to promote the biofuel sector in India is very encouraging, experience has show that the government's initiatives have not translated into results on the production and commercialization fronts to meet the country's energy demand. This calls for a re-examination of the policy from various stages of the biofuel supply chain.

The policy focuses on ethanol production from molasses, a process that is plagued by price volatility, combined with demand for molasses-based alcohol from the potable and chemical industries. Its production is dependent on sugar production. Volatility in sugar production affects molasses availability. This is already evident as the viability of blending mandates is at stake as the EBPP has not been successfully implemented across the country owing to the non-availability of ethanol for blending on a continuous basis.

The policy is thus sugarcane-centric which is counterintuitive to the policy recommendation of using degraded and less fertile land for biofuel production. Sugarcane is a big beneficiary of subsidies on fertilizer, pesticide and electricity for irrigation. The policy not only favors production of ethanol from sugarcane through molasses but also recommends sugarcane juice as another option. While mention is made of other feedstocks like sweet sorghum, sugar beet etc., prominence and a clear roadmap are not specified. In view of the above, prioritization of alternative feedstocks to fulfill targeted blending mandates is called for. Policies favoring alternative feedstock such as sweet sorghum by capping a third of the 5-10% requirement will serve as an incentive. A small subsidy in the initial years will go a long way in promoting alternative feedstocks which can supplement ethanol production for blending requirements.

The biofuel policy veers towards the supply side. Demand side factors like providing consumption support also play a significant role in promoting biofuels. Promoting of flex-fuel vehicles designed to use higher percentage blends of ethanol as in Brazil, is a classic example. Similarly, reducing registration fees and road tax exemptions for vehicles running on biofuels are common in many countries. Policy sops similar to the ones approved by the MNRE for the dissemination and promotion of battery-operated vehicles (BOV) will also help in promoting and sustaining the biofuel industry, and should be provided in the initial years (5-10) until the industry becomes self-sustaining.

Modifications in the National Policy on Biofuels favoring bioethanol production from alternate feedstocks like sweet sorghum will benefit all the stakeholders in the biofuels supply chain and will quicken the pace of biofuel production in the country to meet blending mandates.

References

Acharya SS and **Jogi RL.** 2004. Farm input subsidies in Indian agriculture. Agricultural Economics Research Review 17(1):11-41.

FAO (Food and Agriculture Organization). 2008. The state of food and agriculture. Rome, Italy: Food and Agriculture Organization. 128 pp.

GOI (Government of India). 2009. National Policy on Biofuels. New Delhi, India: Ministry of New and Renewable Energy. 18 pp.

Rao Dayakar B, Ratnavathi CV, Karthikeyan K, Biswas PK, Rao SS, Viyay Kumar BS and **Seetharama N.** 2004. Sweet sorghum cane for biofuel production: A SWOT analysis in Indian context. Hyderabad, Andhra Pradesh, India: National Research Center for Sorghum. 20 pp.

Reddy BVS, Ramesh S, Ashok Kumar, A, Wani SP, Ortiz R, Ceballos H and **Sreedevi TK.** 2008. Biofuel crops research for energy security and rural development in developing countries. Bioenergy Research 1:248–258.

Reddy BVS, Ramesh S, Sanjana Reddy P, Ramaiah B, Salimath PM and **Rajashekar Kachapur.** 2005. Sweet sorghum - A potential alternative raw material for bio-ethanol and bio-energy. International Sorghum and Millets Newsletter 46:79-86. Patancheru 502 324, Andhra Pradesh, India: ICRISAT.

Shinoj P, Raju SS and **Joshi PK.** 2011. India's biofuel production programme: Need for prioritizing alternative options. Indian Journal of Agricultural Sciences 81(5):391-397.

Srinivasa Rao P, Reddy BVS, Blümmel M, Subbarao GV, Chandraraj K, Sanjana Reddy P and **Parthasarathy Rao P.** 2009. Sweet sorghum as a biofuel feedstock: Can there be food-feed-fuel tradeoffs? ICID. http://www.wg- crop.icidonline.org/ sweet%20sorghum_dec09.pdf

Steenblik R. 2007. Biofuels – at what cost? Government support for ethanol and biodiesel in selected OECD countries. Geneva, Switzerland: Global Subsidies Initiative, International Institute for Sustainable Development. 82 pp.

TERI (The Energy and Resources Institute)**.** 2007. TERI energy data directory and yearbook 2006-07. New Delhi, India: TERI. 527 pp.

Tyner WE and **Taheripour F.** 2007. Biofuels, energy security, and global warming policy interactions. Presented at the National Agricultural Biotechnology Council Conference, 22–24 May 2007, South Dakota State University, Brookings, SD, USA.